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Testing in a Joint Environment 2004–2008: Findings, Conclusions, and Recommendations from the Joint Test and Evaluation Methodology Project

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The Office of the Secretary of Defense chartered the Joint Test and Evaluation Methodology project to institutionalize testing in a joint environment. The project has now finished most of its major activities. In this article we describe our key accomplishments, findings, conclusions, and recommendations. Testing in a Joint Environment refers to tests of military systems as participating elements in overarching joint systems of systems. The concept first appeared in Strategic Planning Guidance and was formally introduced as Department of Defense policy in a roadmap signed by the Deputy Secretary in 2004. Several working groups were formed to implement the roadmap. The Joint Test and Evaluation Methodology project was initiated in 2005 to continue efforts of the methods and processes working group. Throughout the past three years we have developed, tested, and evaluated a number of methods and processes for defining and using a distributed live, virtual, and constructive joint test environment to evaluate system performance and joint mission effectiveness. We briefly describe those processes, what we learned by testing them, and the extent to which they improve the ability to conduct tests, across the acquisition life cycle, in realistic joint mission environments. We also describe the results of two large-scale distributed tests—INTEGRAL FIRE 07 and Joint Battlespace Dynamic Deconfliction 08—which used mixes of live, virtual, and constructive elements to test a number of systems in joint environments. Several challenges remain, and we make recommendations to continue progress toward the goals of testing in a joint environment. The Department's long-term strategy calls for evaluations of joint system effectiveness throughout all phases of all weapon systems' development and deployment.

Key words: Acquisition; joint test environment; joint mission effectiveness, testing, methods, processes, planning; planning; rehearsal-of-concept (rock) drills; simulations, live, virtual, constructive.

The Joint Test and Evaluation Methodology (JTEM) project was initiated in February 2005 by the Director of Operational Test and Evaluation (DOT&E). We were directed to investigate, evaluate, and make recommendations to improve the ability to test across the acquisition life cycle in realistic joint mission environments. Our focus was to be on methods and processes for testing in a joint environment. The concept of "testing in a joint environment" comes from U.S. Department of Defense (DoD) 2006–2011 Strategic Planning Guidance for Joint Testing in Force Transformation. It refers to tests of military systems as participating elements in overarching joint systems-of-systems. Over the past three-plus years, we developed and applied several processes and test methodologies. Many are refine-

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ments to current test and evaluation procedures; but some are not. In this article we discuss three of the more significant changes in test and evaluation (T&E) procedures needed to make testing in a joint environment a routine part of defense system development. First, testing in a joint environment must be integrated into each acquisition program's T&E strategy. Second, test events take on several new dimensions, especially during development testing. And third, the evaluation of test results brings together warfighters and developers in new and challenging ways.

Because the concept of testing in joint environments originated in transformation planning guidance, it is fundamentally transformative in nature. And transformation, we discovered, is hard. The DoD's goal is to define, develop, and then test new military systems in the context of how we fight, i.e., jointly. But while war fighting is now an inherently joint process, defense systems acquisition is inherently not. And that is the overarching challenge to testing in a joint environment. The *Testing in a Joint Environment Roadmap* (DoD, 2004a), coordinated by DOT&E in 2004, remains the only official document directing testing in a joint environment. The roadmap identifies changes to policy, procedures, and test infrastructure needed to routinely conduct T&E in joint environments. The approved roadmap makes testing in a joint environment clear Department policy and calls for all programs, regardless of acquisition category, to demonstrate their joint capability early and throughout their respective development cycles. But acquisition programs, by statute, are initiated, funded, and managed within military services. The roadmap still defines a desired end state, but the Department has yet to bridge the gap between this end state and current practice. This theme is echoed in conclusions and recommendations discussed later.

A key aspect of JTEM's direction from DOT&E was using a distributed live, virtual, and constructive (LVC) joint test environment to evaluate system performance and joint mission effectiveness. The *Testing in a Joint Environment Roadmap* authors quickly concluded that no single test facility could consistently provide sufficiently robust joint environments. The authors saw modern networks and rapidly improving simulations as the means to overcome single-facility limitations. Networks could make several different and geographically dispersed test facilities appear as one. Networks also allow operator or hardware-in-the-loop simulations (sometimes called *virtual* simulations) to substitute for live systems and digital computer simulations (sometimes called *constructive* simulations) to substitute for live or virtual systems in a joint test environment. Combinations of live, virtual, and constructive simulations—linked through networks into a single distributed environment—could then form *LVC* joint mission environments for testing. A substantial portion of JTEM resources went to systems engineering activities used to integrate simulations into a distributed environment. As it turned out, these technical activities were relatively easy compared to the nontechnical challenges discussed in this article.

During the past three years we used various activities as settings for testing and evaluating evolving versions of methods and processes. Some observers have likened this to making a movie about people who are putting on a play. Just as the play is a backdrop for the movie characters, JTEM activities were backdrops to evaluate processes for testing in a joint environment. Initially we used Rehearsal of Concept (ROC, sometimes spelled *rock*) drills (U.S. Marine Corp, 2001) for initial process evaluations. Rock drills involved representative users conceptually walking through processes without actually conducting a test. We used these drills for initial process shakedowns to uncover major problems before applying the processes during distributed LVC events. In 2007 the distributed event was the Air Force's INTEGRAL FIRE, and in 2008 it was the Army's Joint Battlespace Dynamic Deconfliction (JBD2). Potential users of JTEM processes applied selected processes during the planning and conduct of these events. Each event included live, virtual, and constructive representations of systems that together accomplished one or more joint missions. JTEM selected some of these systems and joint missions as notional test items. We then used data collected during the events to evaluate system performance and mission effectiveness in a joint environment.

The emphasis in this article is on the more difficult future challenges facing the DoD if testing in a joint environment is to become an achievable goal. In terms of current processes, these challenges start with Test and Evaluation Master Plans (TEMPs). The next section explains the planning information needed in TEMPs to make testing in a joint environment an integral part of an acquisition program's T&E strategy. Then we describe some enduring relationships among test organizations needed to make distributed LVC testing a routine part of development and operational tests. Next we identify how results of tests in joint environments must be evaluated concurrently by developers, operational testers, and end users. We conclude with some recommendations that span these three areas. None of these changes is prohibited by current policy, directives, or law. However, they represent transformative, cultural changes, and they may require substantial commitments of resources.

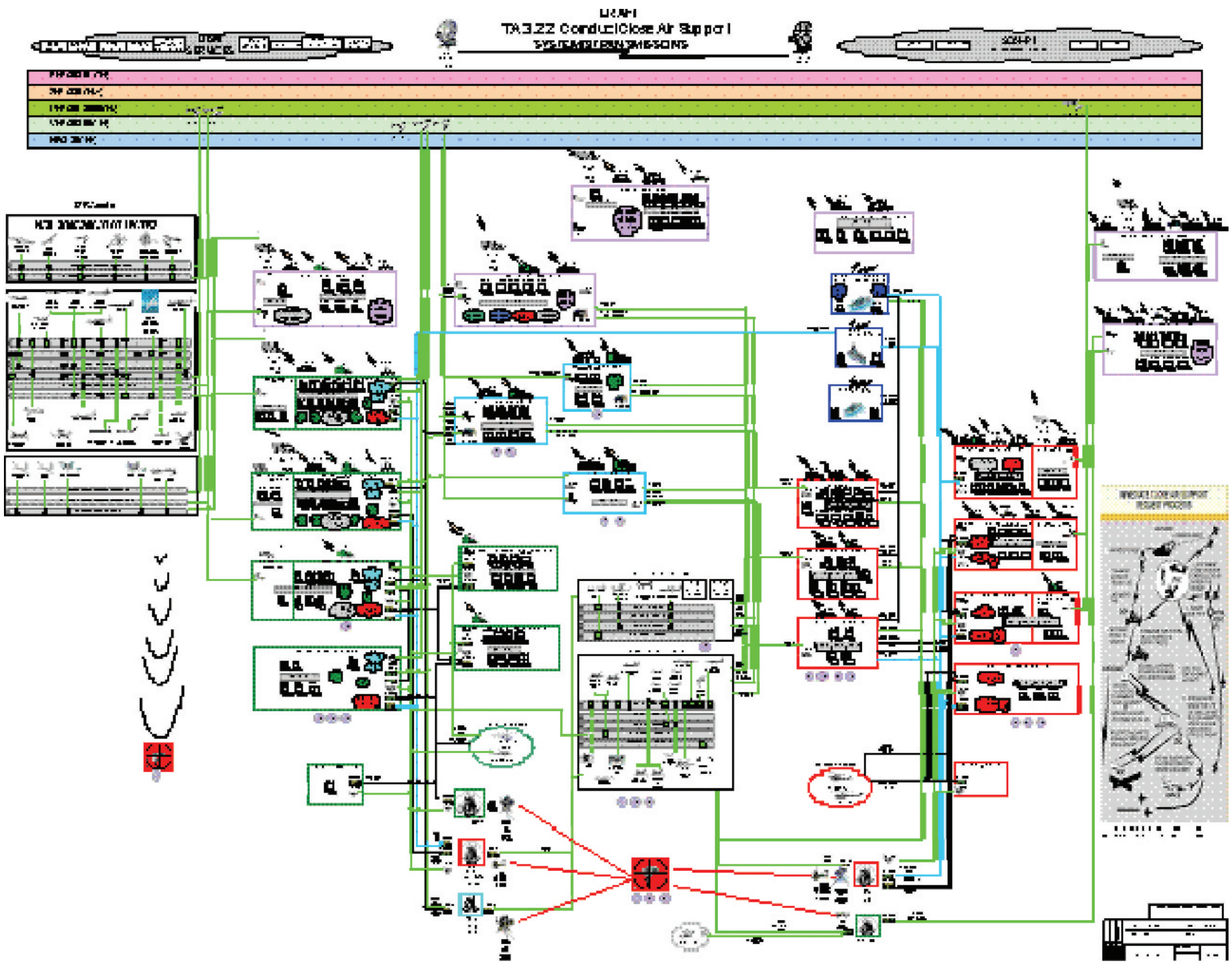

Figure 1. JFCOM Joint Architecture for close air support.

T&E master plans

From the beginning we recognized the importance of addressing testing in a joint environment in each program's TEMP. For one thing, if testing in a joint environment is not part of the TEMP, then testing in a joint environment is not resourced. But while integrating testing in a joint environment into master plans seemed straightforward at first, it turned out to more difficult than we expected. We gathered information on TEMP modifications for testing in a joint environment during workshops with the Operational Test Agencies (OTAs) and as part of early planning for one of our distributed test events. The OTA workshop concentrated on those parts of a TEMP of most interest to an OTA—Initial Operational Test and Evaluation (IOT&E) to support a full rate production decision, operational assessments conducted periodically throughout development testing, and resourcing for both. Early planning for our second distributed test event attempted to broadly define the joint operational context for the tests using guidance from current joint doctrine and tasks.

During our workshop, the OTAs had many questions about how to build a TEMP incorporating testing in a joint environment, but two are particularly noteworthy. Senior technical leaders were looking for guidance on how to insert testing-in-a-joint- environment events into the overall test schedule. One sensible answer is to have OTAs conduct testing in a joint environment during traditional Operational Assessments (OAs) or even early operational assessments. OAs do not carry the same restrictions on simulation use as IOT&E. Hence OTAs could provide valuable operational insight into design alternatives when the developer may be working with relatively easy-to-change constructive or virtual prototypes. And if such events are to be conducted in realistic joint mission environments, then OTAs are better positioned to plan them. This leads to the second question: Because joint mission environments necessarily include tactics, tech-

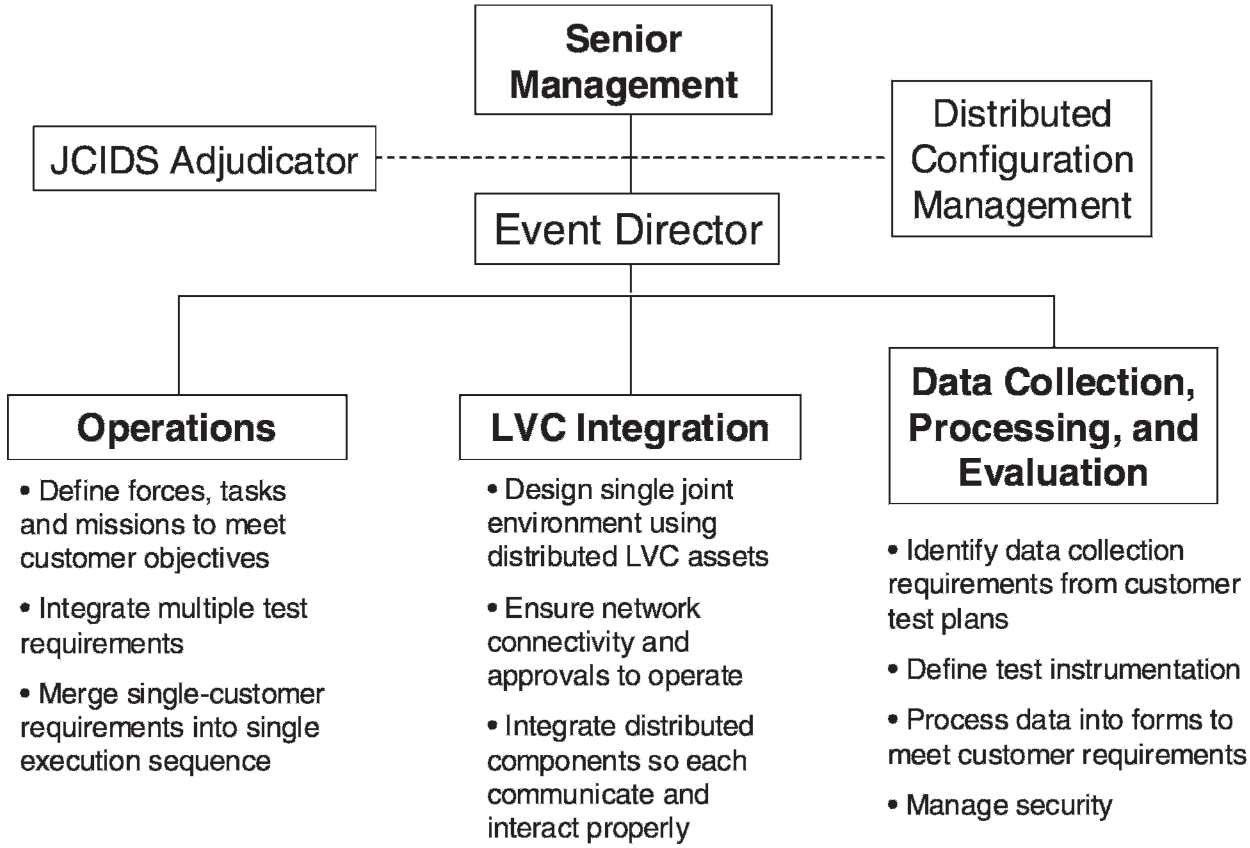

Figure 2. Most effective functional organization based on JTEM events.

niques, and procedures (TTPs) for employing the system under test, how do you plan for situations when current TTPs are clearly inappropriate for the new system? A complicating factor, as we discuss later, is that system effectiveness may depend on TTPs, and vice versa.

We also addressed some TEMP information during early planning for our second distributed event. The Army used the JBD2 event to integrate distributed components in support of future test requirements. Working with Army event coordinators, our intent was to define a broad joint operational context for the test based on current joint doctrine (DoD, 2004b) and the Universal Joint Task List. However, as might be expected, we found current doctrine and training tasks a poor fit for future capabilities. We were also hampered by the lack of documentation from the Joint Capabilities Integration and Development System (JCIDS) (DoD, 2007). Capability Development Documents and Capability Production Documents, for example, should address future doctrine adjustments that will be needed when the capability is fielded. And certainly these doctrine requirements should be used as a starting point for testing-in-a-joint-environment operational concepts. When available and appropriate, another good starting point would be joint architectures provided by U.S. Joint Forces Command (JFCOM). *Figure 1* shows an example for close air support (DoD, 2003).

But normally the effectiveness of proposed future doctrine will be uncertain until after some field trials. We have concluded that a sensible approach to master plans for testing in a joint environment is to test nonmaterial doctrinal concepts along with the material solution to a joint capability gap. But this is not how most acquisition programs are currently managed.

Relationships among test organizations

An important objective of JTEM distributed events was to evaluate the effectiveness and suitability of working group structures. Our goal was to use these evaluations to recommend organizational relationships and functions appropriate for a persistent distributed LVC test *range*. This *range* should be able to support future testing in a joint environment on a regular basis. INTEGRAL FIRE used three primary working groups and one overarching group to coordinate among the first three. JBD2 created six primary working groups. Combining lessons learned from these two constructs, we identified three basic functional

areas needed to effectively conduct distributed LVC testing. Within a single test organization, these activities might fall within current range management, range operations, and data management units. For our distributed events, involving multiple test organizations, the functional areas were operations, LVC integration, and data-related functions. *Figure 2* includes a few more details. Two fundamental assumptions behind *Figure 2* are (a) multiple test customers are participating in each test event, and (b) each individual customer has an approved test plan. The latter mirrors typical single-range procedures where a customer cannot enter the scheduling process without an approved test plan or similar document. Test organizations should consider some permanent cross-organizational relationships to accomplish the functions in *Figure 2*, including approval procedures for test plans requiring distributed LVC events.

A few other aspects of *Figure 2* require some clarification. For example, JCIDS adjudication would entail resolving real or apparent inconsistencies among joint mission requirements. Distributed configuration management is clearly necessary and might best be handled by a group encompassing configuration managers at participating test organizations. We should also point out INTEGRAL FIRE and JBD2 had compressed timelines and focused on single events at predetermined, fixed dates. Activities were necessarily focused on constructing distributed environments, executing operational missions, and collecting data with whatever assets happened to be ready on test day. Early test planning was rushed, and detailed test planning was inconsistent across events and customers. INTEGRAL FIRE had fewer problems, due in no small part to its overarching coordinating group. Hence such a coordinating function will be critical to the success of future distributed LVC tests.

Evaluation of test results

We defined notional test items—systems and associated joint missions—during our distributed LVC events to create opportunities to apply our proposed processes for the evaluation of test results. For example, INTEGRAL FIRE included a constructive network enabled weapon (system under test) employed in support of joint close air support missions. INTEGRAL FIRE also included a constructive surface-to-surface missile used for joint fire support missions (DoD, 2006). During test trials, calls for fire support and air support requests were sequenced to intentionally create airspace conflicts. Conflicts were then resolved using current joint airspace control doctrine (DoD, 2004). The constructive network enabled weapon (NEW) was an air-launched, bomb-on-coordinates, sub-500-pound-class guided bomb with data link capabilities. The weapon's data link mode with third party targeting was evaluated in these tests. In this mode, target coordinates stored in the weapon are updated after launch by either another aircraft or a ground-based Joint Terminal Attack Controller. Before the weapon will accept updated coordinates, the launching aircraft must hand off control of the weapon to one of these *third parties*. The constructive NEW model was designed to implement handoff procedures contained in draft operating concepts (Air Combat Command, 2006). These procedures are outlined in *Figure 3*.

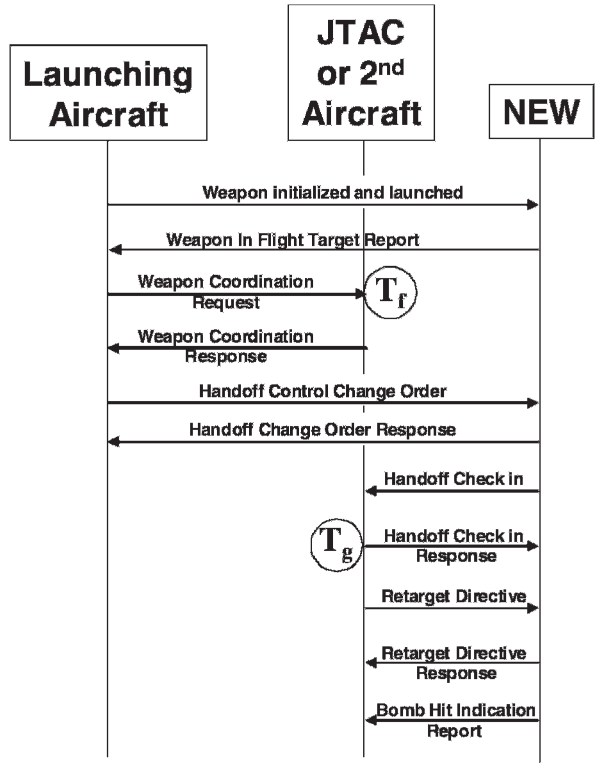

Figure 3. Procedures used in INTEGRAL FIRE to handoff weapon control.

For the purposes of providing an example application of JTEM evaluation processes, postlaunch handovers of NEW control were conducted to determine the ability of pilots and Joint Terminal Attack Controllers to perform handoff functions in a joint mission environment. Each trial included a postlaunch handoff of NEW control by the launching aircraft. Prior to weapon launch, pilots of the launching aircraft coordinated handover of weapon control to either a Joint Terminal Attack Controller or a second aircraft. Handoff time (time interval from T_f to T_g) measured the effectiveness of each handoff. Test results showed that handoffs to the second aircraft were relatively fast when the airspace control volume was small, but

relatively slow when larger airspace control volumes were used. This result indicates interdependence between joint airspace control doctrine and weapon design mechanization during the test. The system-acquisition question is: Should the developer modify the weapon design or should the operational community modify doctrine? Who decides? We recommend the DoD clarify responsibilities to account for these inevitable material–nonmaterial dependencies. We also believe better guidance is needed, in general, on how evaluations of joint mission effectiveness are to be used by milestone decision authorities to support decisions such as continued development, full-rate production, or fielding.

Summary

Through our rock drills, distributed LVC events, and related activities, the JTEM project has been able to sustain some momentum toward institutionalizing testing in a joint environment. In addition to the conclusions and recommendations discussed, our final report will contain many other technical and nontechnical findings. For example, test infrastructure investments are currently not managed with a distributed, joint test environment in mind. And the opposing-force side of the equation remains largely ad hoc (although the Test and Evaluation Threat Resource Activity has jumped in to tackle some aspects of the problem). Overall, JTEM has contributed to building the foundation for a solid community of interest for distributed LVC testing. Test organizations across the services are now better prepared to support testing in a joint environment when requirements are formally communicated to acquisition program managers. ❑

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